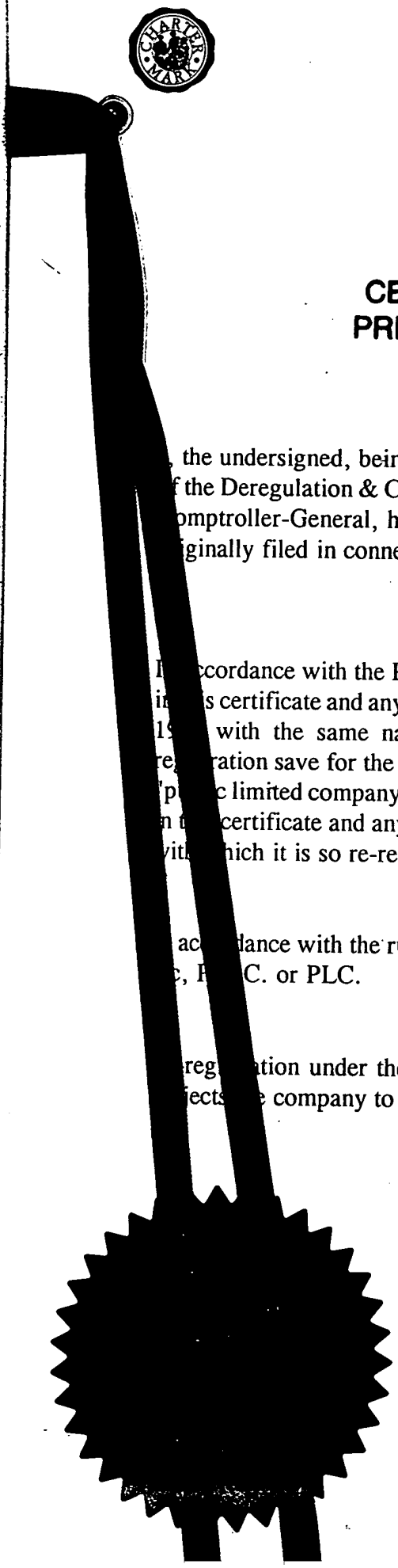

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, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) f the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the omptroller-General, hereby certify that annexed hereto is a true copy of the documents as iginally filed in connection with the patent application identified therein.

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Signed

Dated 21 June 2001

#5

Attorney Docket: 3036/50060
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: ANDREW REEVE

Serial No.: NOT YET ASSIGNED

Filed: JULY 5, 2001

Title: IMPROVEMENTS IN OR RELATING TO BUFFER MANAGEMENT

CLAIM FOR PRIORITY UNDER 35 U.S.C. §119

Box PATENT APPLICATION July 5, 2001
Commissioner for Patents
Washington, D.C. 20231

Sir:

The benefit of the filing date of prior foreign application No. 0016474.9, filed in Great Britain on 5 July 2000 and application No. 0024735.3, filed in Great Britain on October 10, 2000, is hereby requested and the right of priority under 35 U.S.C. §119 is hereby claimed.

In support of this claim, filed herewith is a certified copy of the original foreign applications.

Respectfully submitted,

Gary R. Edwards
Registration No. 31,824

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Request for grant of a patent

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The Patent Office

Cardiff Road
Newport
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1. Your reference

2000P04896/GB/R76/MM/rr

2. Patent application number
(The Patent Office will fill in this part)

0016474.9 05 JUL 2000

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

ROKE MANOR RESEARCH LIMITED
OLD SALISBURY LANE
ROMSEY
SO51 0ZN
UNITED KINGDOM

Patents ADP number *(if you know it)*

07615455006

If the applicant is a corporate body, give the country/state of its incorporation

UNITED KINGDOM

4. Title of the invention

REASSEMBLY BUFFER MANAGEMENT

5. Name of your agent *(if you have one)*

DEREK ALLEN

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Siemens Shared Services Limited
Intellectual Property Department
Siemens House, Oldbury
Bracknell, Berkshire RG12 8FZ
United Kingdom

Patents ADP number *(if you know it)*

07964190002

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

NO

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Abstract	0
Drawing(s)	0

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Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature M D Mackett Date 05.07.2000

Magaret MACKETT

12. Name and daytime telephone number of person to contact in the United Kingdom: Margaret Mackett - 01344 396808

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REASSEMBLY BUFFER MANAGEMENT

The present invention relates to reassembly buffer management. In particular, the invention relates to a method for reassembling variable length Internet Protocol (IP) packets from fixed length Asynchronous Transfer Mode (ATM) cells in the absence of reassembly timers.

In the Internet, data is transferred over a global network of heterogenous computers by means of a plurality of routing devices in accordance with a standard protocol known as Internet Protocol (IP). IP is a protocol based on the transfer of data in variable sized portions known as packets. All network traffic involves the transportation of packets of data.

In Asynchronous Transfer Mode (ATM) networks, data is transferred in small cells of a fixed length, typically carrying 48 bytes of data. ATM allows high transmission rates by keeping the overheads due to communication protocols to a minimum and by implementing the majority of the communication protocols in hardware. In particular, ATM routing is achieved entirely in hardware. In ATM, virtual circuits between senders and destinations called virtual channels are established, the set-up and the maintenance of the virtual channels being implemented in hardware to minimise switching delays.

Routers are devices for accepting incoming packets; temporarily storing each packet; and then forwarding the packets to another part of the network. For the purposes of the following description the term routing device refers to any device which performs the function of a router or a circuit switch. One relevant example of a routing device is an ATM to IP switch. There is an urgent requirement for routing devices that can route IP

traffic at extremely large aggregate bandwidths in the order of several terabits per second. Such routing devices are termed "terabit routers".

When an IP packet is transmitted between routers over an ATM link, the packet must be segmented into fixed length ATM cells. The receiving router must reassemble the original packet from the cells as they arrive.

Conventional reassembly proceeds as follows:

Firstly, a free pool of packet buffers (or reassembly buffers) is maintained. Secondly, on arrival of the first cell for a given packet, a packet buffer is allocated from the free pool. Packet data is copied from the cell into the buffer and a timer is started. The timer is known as a reassembly timer whose function is to protect the system from lost cells.

Upon arrival of each subsequent cell for the given packet, except the last, packet data is copied from the cell into the buffer. After each copy event, the reassembly timer is restarted.

On arrival of the last cell for the given packet, packet data is again copied from the cell into the buffer and the reassembly timer is stopped. The newly complete packet is processed and transmitted to its intended destination or destinations. The buffer is then returned to the free pool.

If the reassembly timer expires, it is assumed that one or more cells have been lost or corrupted. In which case the reassembly is abandoned and the buffer is returned to the free pool.

It is important to note however that the router must perform multiple concurrent reassemblies. Typically the router will have a number of ATM virtual circuits open, each carrying data from IP packets. Within any one virtual circuit, the cells for a given packet will arrive contiguously. However the cells for the given packet arriving on different virtual circuits will be interspersed relative to one another, which also means that cells from different packets will be interspersed. It is possible that concurrent

reassemblies be required for each virtual circuit, each requiring its own timer. For high capacity routers with large numbers of virtual circuits, large numbers of timers are required.

It is therefore an object of the invention to obviate or at least mitigate the aforementioned problems.

In accordance with one aspect of the present invention, there is provided a method for reassembling variable length packets from fixed length cells.

An advantage of the present invention is that it allows the reassembly of variable length packets from fixed length cells in the absence of reassembly timers.

Consider a terabit router having a plurality of interface units, for example RipCore, each interface unit has to support interface speeds of 2.5, 10 and 40 Gigabits per second. Therefore, packet handling has to be as simple as possible to allow the higher levels of hardware integration required and reduce development risk.

In an embodiment of the present invention, the following steps are implemented on a terabit router:

Firstly, a packet buffer free pool is maintained as a linked list. The linked list is known as a 'free list'.

When the first cell for a given packet arrives, the buffer is taken from the head of the free list, the packet data from the first cell is copied into the buffer and the buffer is moved to the end of the free list.

On arrival of subsequent cells for the given packet, excluding the last, the packet data is copied into the buffer and the buffer is moved to the end of the free list.

On arrival of the last cell for the given packet, the packet data from the last cell is copied to the buffer and the complete packet is processed.

If cells for a packet are lost, the buffer will eventually, as a result of buffer allocations for other packets, reappear at the head of the free list and be re-used for a new packet. The failed reassembly is automatically abandoned.

It will be readily appreciated that this technique could also be used for protection against certain so-called "denial of service" attacks upon computer networks.

IP supports packet fragmentation to allow large packets to be transmitted over networks which contain links with physical limits on their packet sizes. Accordingly a large packet may be broken into a number of small packets to be reassembled at their ultimate destination. This makes the network vulnerable to attack. A hostile agent may send to its target a large number of single fragments each identified as belonging to larger packets, but for which no subsequent fragments are sent. The target (using a conventional reassembly scheme as described above) will reserve resources for each reassembly, resulting in buffer exhaustion. It is difficult to combat this sort of attack through the use of reassembly timers since if the timers were to be short enough to be effective, they would not be long enough to accommodate the arrival of real fragmented packets.

A target using a reassembly scheme in accordance with the present invention is much less likely to suffer buffer exhaustion under such denial of service attacks. Bogus fragments do waste bandwidth but have no ultimate effect on the free pool.